THE AMERICAN PHILOSOPHICAL SOCIETY

THE general meeting of the American Philosophical Society was held in Philadelphia on April 20, 21 and 22. The following papers were presented:

Our contradictory economic policy: E. M. PATTERSON.

The distribution of human ability in Europe: ELLSWORTH HUNTINGTON. The ability of a country depends not only on training and social environment, as has long been recognized, but also on inheritance, as is now rapidly becoming apparent, and on health or energy, a factor which has been much neglected. Europe affords one of the best fields in which to differentiate the influence of these three factors. Four lines of evidence are here used for this purpose: (1) the kind of contribution to human progress made by about 8,600 eminent Europeans who were born since 1600 and who are mentioned in the *Encyclopedia Britannica;* (2) the distribution of progress and of civilization according to the opinion of fifty experts in North America, Europe and Asia; (3) the distribution of health and energy as measured by the death rate; and (4) the distribution of climatic conditions that are favorable or unfavorable to health.

The eminent men mentioned in *Britannica* have been classified as follows: (1) religion and philanthropy; (2) philosophy and education; (3) natural sciences; (4) mathematical and chemical sciences and inventions; (5) history and economics; (6) literature; (7) art; (8) politics, and (9) war and adventure. This classification shows striking differences from country to country. For example: in proportion to the number of its people Switzerland, with its 107 representatives in *Britannica,* is very strong in religion, philosophy and the two branches of science, but falls low in all other lines; Scotland and Germany resemble Switzerland, except that the contrast between the extent to which their great men have devoted themselves to religion, philosophy and science on the one hand and to other lines of effort on the other is relatively not quite so great as in Switzerland; France, on the contrary, tends in the opposite direction, for religion and philosophy are comparatively neglected, while literature, art, politics and war are the lines toward which the French type of mind turns most strongly; Ireland follows the French type except that religion also receives emphasis, while the relative importance of war and especially politics rises very high.

Such contrasts and many others are presumably due in part to social environment but probably they also depend partly on racial inheritance. There seems to be no sociological reason why among the 1,737 eminent Frenchmen and 1,185 eminent Germans who appear in the encyclopedia the adjusted index numbers showing the extent to which the two countries have excelled in the various lines of human effort should be as follows: war, France 125, Germany 70; politics, France 105, Germany 49; history, 101 and 171; and philosophy, 83 and 214. Or take the following contrasts between the relative numbers for the 604 Scotch and 292 Irish: politics, Scotland 83, Ireland 164; mathematical sciences, 139 against 72, and natural sciences, 140 against 65. It seems as if these figures might be a rough index of certain deep-seated racial tendencies which manifest themselves in the whole social organization and history of the various countries.

When an attempt is made to show the geographical distribution of mental tendencies among the eminent men of Europe, the result is a series of erratically spotted maps which in many cases indicate little or no connection with environmental factors. Nor do they correspond at all closely to the fairly gradual and progressive character of the changes in social and sociological conditions from one part of Europe to another.

A map of the progressiveness or civilization of the countries of Europe as judged by fifty experts before the war, shows an aspect wholly different from that of the maps of special types of achievement. It displays an almost perfect gradation from higher to lower levels as one proceeds away from the regions bordering the North Sea. There are no sudden breaks from country to country. The distribution seems to be governed by factors which vary gradually and regularly from region to region instead of spasmodically and irregularly as in the previous cases.

A map of health based on the death rate before the war is almost identical with the map of civilization. The figures for all countries have been reduced to a standard population. Children under one year of age and old people of seventy-five or more have been omitted because an analysis of the statistics shows that in many countries the records of deaths at these two extremes of age are peculiarly unreliable. The way in which the map of health shows a decline in human strength and ability as one proceeds away from the North

Sea suggests a controlling factor akin to that which determines the distribution of civilization. Among the physical factors most likely to be related to human ability, climate holds high rank. A map of climatic energy based on a comparison between climatic factors on the one hand, and millions of deaths, thousands of cases of disease, and the work of thousands of factory operatives on the other, is almost identical with the maps of civilization and of health, but wholly different from any of the maps showing the distribution of particular types of achievement.

The resemblance of the maps of civilization, health and climatic energy is so great that it seems almost certain that there must be some common cause. Civilization undoubtedly has an influence on the distribution of health, but it cannot possibly affect the distribution of climate. Health likewise influences civilization, but cannot influence climate. Climate, on the other hand, may have some direct bearing on civilization, and it certainly produces indirect effects through agriculture, food and otherwise. It also has a great influence upon health, and its action upon civilization in this way is probably greater than its direct effect or perhaps than the indirect results arising through agriculture and food. The most reasonable explanation of the similarity of the three maps seems to be that climate influences health and health influences civilization.

The similarity of climate, health and civilization in their distribution in space appears to be supplemented by an equally strong similarity in their distribution in time. This matter has not yet been investigated in Europe, but in the United States variations in the weather from season to season and year to year are reflected with great fidelity in variations in the death rate and in the amount and character of work done by factory operatives on the one hand and students on the other. In other words, the quality and rapidity of people's work, that is, their ability, varies in harmony with the general health of the community and both vary in harmony with the weather. The order of the relationship can scarcely be other than weather, health, ability. Thus, whether we consider space or time, climate seems to be one of the determinants of the degree of ability of a race. On the other hand not only is racial inheritance presumably an important factor in determining the energy of a race, but in Europe, at least, it seems to be of great weight in determining the direction in which human energy shall direct its activities. Thus sociological environment seems to be largely the result of the interaction of human energy whose general distribution is greatly influenced by climate, and of racial inheritance which determines the lines along which nations shall express themselves in ideas and institutions.

George Hammond and Robert Liston—British ministers in Philadelphia, 1791-1800: J. F. JAMESON.

The Three Trinities: E. WASHBURN HOPKINS. Trinities must be sharply differentiated from triads; every trinity is a triad, but few triads are trinities. Examples from Greece and Persia. In India the first triadic union was that of the three fires, of earth, atmosphere, sky; but this was rather one god in three places than three forms of a god. The popular trinity of Brahman, Vishnu and Shiva was a theological compromise and has never had philosophic support. But the later trinity of the Ramanuja sect implies a Father God, an Absolute Brahma, and an incarnate human form of the godhead. A similar development is to be traced in the theistic Buddhism which has always been more potent than the doctrine of the Madhyamikas. The Christian or Greek trinity combines in the same way the ideas of godhead, personal God and incarnate divinity. At the base, all three are attempts to express the same religious-philosophical conception of a spiritual source of the world manifested as personal spirit in heaven and in human form on earth. Possibility of subsuming these three trinities under one head, a new trinity that might unite the three great religions.

The use of devices for indicating vowel length in Latin: JOHN C. ROLFE. In the pronunciation of Latin of the classical period great importance was attached to the quantity of vowels. From the time of Sulla until about 300 A. D. the Romans employed various devices for indicating vowel length, especially the apex, which usually had the form of an acute accent, and a tall I, to indicate the long form of that vowel. These marks are found in inscriptions, but all the long quantities are almost never indicated in any one inscription. The paper attempts to discover some of the principles according to which the marks are used. The examination of the "Monumentum Ancyranum," a copy of the inscription in which the Emperor Augustus recorded the deeds of his reign, of the speech of Claudius at Lyons in 48 A. D., and of several thousand shorter inscriptions indicates that the marks are frequently used with personal names, with titles of honor and for

emphasizing some other words, with words denoting family relationships, with suffixes, prefixes and case-endings, and sometimes, apparently, to indicate punctuation. Although Quintilian says that their proper use was to distinguish words and case-endings which are alike in spelling but different in quantity, that rule is comparatively seldom followed in the extant inscriptions.

A sketch of the modern faeroe dialect: J. DYNELEY PRINCE.

The novæ or "new stars": E. E. BARNARD. This paper dealt with the peculiarities of the novæ or "new stars." These are not new stars in the ordinary sense of the word. They are stars whose original condition was very faint or even beyond the reach of any telescope, that suddenly, from some unknown cause, become very bright even to the naked eye—in some cases increasing their light as much as a hundred thousand fold. They then fade away, perhaps never to become bright again. All of this great increase of brightness occurs within a few hours' time, or a few days at most. The outburst of light is very sudden; the decline is at first rather rapid, then slower, and with many halts and minor outbursts they finally in a few years' time, say from eight to ten or fifteen years, return to their original brightness. This interval seems to vary with different stars. Some of these wonderful objects, such as the great nova of 1572, have become visible to the naked eye at midday. Two of them in recent years became brighter than the first magnitude. One of these, Nova Aquilae of 1918, for one day outranked every star in the entire heavens except Sirius and possibly Canopus. At first we did not know anything of the previous history of these strange stars. They suddenly appeared as if a new star had just been created. But in recent years photography has added much to our knowledge of them. Now when a nova appears we search for it on our photographic plates made before the star's outburst. Sometimes we find that previous to this outburst the star was beyond the reach of even the photographic plate, while in other cases they are shown to have formerly existed as very small stars with nothing to distinguish them from the millions of other small stars that dot the sky. In several instances we have found that previous to its outburst the nova had existed as a faint variable star, rhythmically changing in brightness by a small amount. The great star of 1901, Nova Persei, is one of these that had probably existed for ages as a small variable before it became a nova. Watched carefully now, this star fitfully varies through a couple of magnitudes, as it probably did in its original condition. What causes the tremendous outburst of light in these wonderful stars is not known.

The message of a meteorite: MONROE B. SNYDER.

The effect of diurnal variation of clock rates upon longitude work: R. H. TUCKER. From observations with the meridian circle, pendulum clocks appear to run faster at night than the average rate during a period of one day. The excess each hour is small, but the daily rate at midnight appears to be from two to three tenths of a second larger than the daily rate at noon. The largest error that would occur in predicting the correction to an astronomical clock would be between two and three one-hundredths of a second. The observed variation may be due to a diurnal variation in the meridian plane. Such a variation, with a period of fourteen months, does occur, owing to the deviation of the axis of rotation of the earth from the axis of figure of the earth. There is a small diurnal term in the observed latitude at the Lick Observatory, the full amplitude of which is about three tenths of a second of arc. Small corrections to the adopted astronomical constants of aberration, or nutation, may be indicated by these anomalies of observation. An exchange of longitude signals between two stations, ninety degrees apart, might give a resulting difference of longitude from two to three one-hundredths of a second in error. Between two stations on opposite sides of the earth the error might be double that amount. Exchange of wireless signals, sent automatically by clocks across the Atlantic, may give us a test of a variation in clock rates.

Discussion of a kinetic theory of gravitation, II; and some new experiments in gravitation: CHARLES F. BRUSH.

Arc spectra and ionization potentials in dissociated gases: K. T. COMPTON, with O. S. DUFFENDACK and P. S. OLMSTEAD. The great complexity of spectra of gases is due, in part, to the fact that the molecules of the gas may exist in various states of dissociation, association and ionization, each type of molecule or atom giving rise to its own characteristic spectrum. A discovery of the exact state of the atoms or molecules giving rise to each part of the spectrum of a substance is of great importance as regards both the theory of spectral emission and the theory of atomic and molecular structure. At the Palmer

Physical Laboratory this problem is being attacked from three different angles. This paper presents some discoveries relating to the excitation of radiation and ionization in hydrogen and nitrogen.

Hydrogen: Two methods of investigation have been employed. In the first, an arc was produced in hydrogen by the electronic discharge from an incandescent tungsten wire to a surrounding coaxial tungsten tube, which could be electrically heated. The voltages at which discontinuities appeared in the current between the electrodes and especially the voltage at which the arc struck indicated the critical potentials for the setting in of radiation or ionization. With the outer tube cold the hydrogen was in the ordinary molecular state. With the outer tube at a temperature near the melting point of tungsten, the hydrogen was completely dissociated into *atomic* hydrogen. Thus the effects due to the molecule and those due to the atom could be definitely distinguished from each other. This is the first experiment ever performed in an atmosphere of pure atomic hydrogen. The following results were obtained: (1) An arc can not be produced or maintained in molecular hydrogen at voltages less than 16 volts, which is the ionizing potential of the molecule. (2) In atomic hydrogen the arc struck easily at 13.5 volts and, with very large electronic currents, at 10.1 volts. These are, respectively, the ionizing and radiating potentials of the hydrogen atom as given by Bohr's theory. (3) The hydrogen line spectrum was observed whenever the arc struck. It was not observed below 16 volts in molecular hydrogen, but was observed as down to 10 volts in atomic hydrogen. (4) The hydrogen secondary spectrum was not observed below 16 volts and the only lines found in this spectrum were those of the group which shows no Zeeman effect. (5) The Balmer series lines were reversed in the hot tube, provided the gas was ionized. The second method was that of Franck and Hertz, modified to permit a variation in the relative proportions of atomic and molecular hydrogen by use of a grid of hot tungsten wires, and to enable effects of radiation to be distinguished from those of ionization. These results corroborated those of the above method and showed, further, that the hydrogen molecule can be ionized without dissociation and that the lines of the Lyman series can probably be separately excited at successively higher voltages.

Nitrogen: In the hot tungsten tube, there was no certain evidence of dissociation into atomic nitrogen by heat alone, but there was evidence that nitrogen was more easily dissociated by electron impacts in the hot than in the cold tube. The atomic nitrogen was chemically active, combining with the tungsten of the tube furnace, and it greatly increased the conductivity of the gas between the electrodes. The presence of atomic nitrogen was indicated by this increased conductivity of the gas or by the emission of lines of the nitrogen line spectrum. The following conclusions have been reached with regard to the nitrogen spectrum: (1) The three groups of positive bands are all due to the neutral nitrogen molecules. (2) The negative bands are due to the ionized nitrogen molecules. (3) The bands of the third positive group are excited at about 7 volts, those of the second positive group are excited below the ionizing potential and decrease in intensity as the voltage is raised above the ionizing potential, those of the first positive group were not observed below the ionizing potential and increased in intensity with increasing voltage, and the negative bands were first observed at one or two volts above the ionizing potential and increased greatly in intensity with increasing voltage. (4) Several new components of bands in the first group of negative bands were discovered, and their wave lengths agreed accurately with those predicted by Deslandre's formula. (5) The line spectrum was not observed below 70 volts, which is also the voltage at which evidence of atomic nitrogen is obtained. The minimum arcing voltage, about 16.5 volts, is due to ionization without dissociation of nitrogen molecules. The relation of these results to observations made in other connections is briefly considered.

Recent developments in vacuum tubes and their use: J. H. MORECROFT.

A primary standard of light: HERBERT E. IVES. The standard investigated is one developed after the suggestion of Wardner and Burgess, namely, the black body or complete radiator at the melting point of platinum. In order to realize this practically, hollow cylinders of platinum are raised to the melting point by the passage of a heavy electric current. The light emitted from a small opening is observed by a photometer upon whose field an image of the cylinder is thrown by a lens. It is found that with highly purified platinum the value obtained for the brightness of the black body is 55½ candles per square centimeter. This standard appears to be more reproducible than any now available, and can be directly correlated with other physical constants.

Surface equilibrium of certain colloid solutions: P. LECOMTE DU NOÜY.

Notes on the ecology of the clovers (trifolium): JOHN W. HARSHBERGER.

The cytoplasm in development and heredity: E. G. CONKLIN. It is generally recognized that the chromosomes of the germ cells are the seat of the inheritance factors or genes, while the cytoplasm of those cells is the chief if not the exclusive seat of embryonic differentiation. Nevertheless it is generally recognized that there is a mutual interaction between the chromosomes and the cytoplasm, and that each may be said to be environment to the other. It is extremely probable that in the course of development the chromosomes and genes undergo little if any differentiation. On the other hand, it is perfectly evident that the cytoplasm does undergo such differentiation. The mechanism of differentiation consists in the reaction of identical chromosomes upon different kinds of cytoplasm. It is therefore impossible to assume that all factors for heredity and differentiation are located in the chromosomes.

The supposed serial arrangement of the genes and its relation to theories of crossing-over in inheritance: H. S. JENNINGS. This paper was a mathematical investigation of the laws according to which hereditary characteristics are distributed to organisms. It was shown that these laws agree in great detail and in many diverse ways with what is mathematically required if the substances on which the hereditary characteristics depend are arranged in the germ cells in serial order, as held by the so-called linear theory.

The relation of the retinal image to animal reactions: G. H. PARKER.

Parallel mutations in oenothera: GEORGE H. SHULL.

Some climatic and topographic characters in the rings of the yellow pines and sequoias of the Southwest: A. E. DOUGLASS. The average growth of the giant sequoia in the General Grant National Park region was found to be 7.6 cm. per century in the last five hundred years. It varies from half of this to double this amount in locations with respectively unfavorable and favorable water supply. Evidence of the climatic origin of cycles in tree growth is found in the extensive areas over which such cycles prevail, and in the historical agreement between variations in tree growth and solar activity. The eleven-year sun-spot cycle appears both in the Arizona pines and in the California sequoias. This cycle has been operating since before 1400, but largely disappeared from about 1640 to 1715, at which time there was a prolonged sun-spot minimum.

The probable action of lipoids in growth: D. T. MACDOUGAL. Renewed interest in the fundamental composition of protoplasm, especially with respect to the importance of the lipoids, or fatty substances, has been aroused by the investigations of the last two years. Czapek in Prague has made additional demonstration of the universal presence and abundance of such material in plant cells, especially in the growing stage. Hansteen-Cranner in Norway claimed to have demonstrated a peripheral deposit of lipoids in the cell with meshworks extending into the wall and into the mass of the protoplasm where it constitutes the fundamental structure. Kahho at Dorpat finds that the contraction and expansion of lupine roots in solutions of neutral salts is in accordance with a condition of permeability which might be due to the presence of such a lipoid layer. Boas at Weihestephan saw that when solutions such as those of saponin, which displace or liquefy lipoids, are applied to plant cells, their permeability is notably increased. Other workers hold to the theory of the primary importance of proteins in the plasma, and as forming the outer or plasmatic membrane. The results of my own work justify the conclusion that all substances which form watery emulsions or set as reversible gels, principally albuminous compounds, mucilages, soaps and lipoids, are to be included in the hydration or growth mechanism. The present paper treats of the results of two series of experiments bearing upon the action of the lipoids. The effects of lecithin were tested by the use of the artificial cell designed in 1921. This lipoid was found to exert but little effect on absorption when incorporated in the "plasma," but to influence absorption in a very marked manner when used as a peripheral layer or "plasmatic" membrane. The solutions which affect the living cell, supposedly by dissolving the lipoidal layer, have a similar effect on the artificial cell. The reactions of living and of dead cell-masses to soponin and hydroxides include variations in swelling and in permeability, which are of a character suggesting the liquefaction of a lipoidal layer. These experiments do not offer decisive evidence of the actuality of such a layer, yet it is notable that nothing was found which could be interpreted adversely to such an arrangement of material in the cell: Material which is abundantly present and which would tend to assume a peripheral

position in a colloidal mass of this character. Furthermore, it is to be noted that the argument against the possibility of a lipoidal membrane on the ground that it would not permit the passage of both fat-soluble and water-soluble material, is voided by the fact that the lipoids may occur in a system in which a disperse phase swelling in water but not soluble, is held in a medium consisting of water-soluble lipoid. Organic substances, fats and salts, would readily pass through such a system.

Possible explanation of eocene climates: EDWARD W. BERRY. This paper discusses the contrast in the floras of the upper Eocene with latitude, and their probable climatic significance. After analysing the fossil floras of the far North in the light of paleogeographic conditions, the speaker suggests that the indicated mild climate in high latitudes during the upper Eocene was the result of the widespread submergence of lands during middle Eocene times, with expanded seas in the equatorial regions and free access of warm ocean currents to Artic seas.

The power and impotence of man: VERNON KELLOGG.

Hydracodons from the Big Badlands of South Dakota. The small entelodonts of the White River Oligocene: W. J. SINCLAIR. These papers present the results of evolutionary studies on two unrelated animal groups, the swift running (cursorial) rhinoceroses and the entelodonts or so-called "giant pigs," both extinct, but formerly inhabiting South Dakota and adjacent areas. In the case of the hydracodons, a progressive evolution is indicated, an increasing complexity of the structure of the upper premolar teeth, with a series of size variants under each of the four structural types recognized. Among the entelodonts, while the extremes of the series studied are far enough apart to appear specifically distinct, there are so many intermediate stages and the grouping of characters is so irregular that almost every specimen would have to be made a separate species or else the lot referred to one species, apparently made up of several inter-breeding strains which differ by various small unit characters or combinations thereof, transmitted to the individual from the various pure lines which enter into its ancestry.

Lithology of White River sediments: H. R. WANLESS. The White River sediments of the Big Badlands are composed of the following types of sediments: (1) channel sandstone; (2) freshwater limestone; (3) nodular layers; (4) volcanic ash beds; and (5) clay beds. A petrographic study of these sediments has shown that most of them are derived from erosion of the rising dome of the Black Hills during the Oligocene period. In the channel sandstones many fragments of garnet, tourmaline and other schist and pegmatite minerals point to direct derivation from the Precambrian core of the hills. Traces of volcanic glass and pumice are present throughout the series, but form the majority of the Leptauchenia beds (the upper division of the White River), which is about two hundred feet thick. Eolian action, as evidenced in rounded sand grains, is only locally present, and forms a negligible part of the whole. Ground water circulation is indicated by chalcedony veins, mineral fillings of cavities in the ash beds, and deposition of oxides of iron at the bottom of the series in and on the impervious Pierre shales. The series as a whole is formed as a flood plain deposit, with shallow shifting channels, local ponds and local sand dunes.

Lava domes and their composition in the Malay Archipelago: H. A. BROUWER.

The application of bio-physical researches to physiological problems: GEORGE W. CRILE and HUGO FRICKE. Following researches on the electric conductivity of animal tissues already presented, a further attempt to apply bio-physical methods to the interpretation of physiological problems has been made by making measurements of temperature variations of various tissues in living animals under varying conditions by means of specially constructed copper-constantan thermocouples. These were used in connection with a specially designed potentiometer and mirror-galvanometer, one division on the galvanometer scale corresponding to 0.01° C. In most of the experiments simultaneous measurements of the temperature variations in two different organs have been made. The principal tissues thus far studied have been the brain, the liver, the thyroid, the adrenals, the voluntary muscles, the spleen, the pancreas, the intestines, the kidneys and the blood stream. The effects produced on the temperature of one or more of these organs by emotion, by adrenalin, by ether, by nitrous oxid, by calcium, by magnesium, by cyanides, by the excision of certain organs, etc., have been noted. The results show that this method of bio-physical measurement offers new criteria for the interpretation of certain operations of the animal mechanism, and emphasizes the value of the application of bio-physical methods of the study of this operation of the animal mechanism.

Experiments in epidemiology: SIMON FLEXNER.

The experiments in epidemiology, carried out with Doctor H. L. Amoss, have been made with an infectious disease arising among mice to which the name of "mouse typhoid" has been given. The bacilli inciting the disease are readily grown outside the body and reproduce the natural disease when fed to healthy mice. The purpose of the experiments, which have extended over three years, is the elucidation of the factors responsible for the epidemic spread of disease among man and animals. Hitherto these factors have been sought chiefly by the analysis of records of disease and death in man; this study represents an effort to obtain more accurate data through direct observation of an epidemic disease purposely induced in small laboratory animals.

Fishes used in Guayaquil for mosquito control against yellow fever: CARL H. EIGENMANN.

The carbonic acid of the blood in health and disease: LAWRENCE J. HENDERSON.

Some recent experiments concerning the nature of the function of the kidney: A. N. RICHARDS.

The Biblical manna: PAUL HAUPT. The biblical manna was manna-lichen mixed with tamarisk-manna and alhagi-manna. The manna-lichen (Lecanora esculenta) was ground in querns, or pounded in mortars, and mixed with the honey-like drops exuding from the soft twigs of tamarisks or with the exudation of camel's thorns. After this mixture had been baked it tasted like honey-cake (Exod. xvi. 31) or like pastry baked in sweet-oil (Numb. xi. 8). In the early morning the tamarisk-manna is like wax, but it melts in the heat of the sun (Exod. xvi. 21). The accounts in Exod. xvi. 14-36 and Numb. xi. 7-9 are inaccurate and embroidered. The ancestors of the Jews were at that time, not on the Sinaitic peninsula, but in northwestern Arabia.

The earth inductor compass: PAUL R. HEYL and LYMAN J. BRIGGS. A model of the U. S. Air Service earth inductor compass, as developed at the Bureau of Standards, and to which the society awarded its magellanic medal, was shown and demonstrated. This instrument is designed for use in aircraft, where the ordinary magnetic compass is unreliable. The fundamental principle of its action is not new, but no previous attempts at the construction of a compass on this principle have given satisfactory results. In the Air Service model a revolving coil of wire is installed in the rear part of the airplane, where the magnetic disturbance from the engine is negligible. Current from this coil is led by wires to the instrument board, where, by an entirely new device called a dial switchboard, the pilot can so arrange the electrical connections that an indicating galvanometer before him will read zero only when the vessel lies in the desired course. An effective compensation for rolling and pitching is provided, and by the judicious use of iron in the core of the coil the size of the instrument is kept down sufficiently to permit of its installation in the limited space available in an airplane.

The age of the earth from the geological viewpoint: T. C. CHAMBERLIN.

Age of the earth from the paleontological viewpoint: JOHN M. CLARKE. The age of the earth from the point of view of the student of the life upon it, can be expressed only in comparative terms. The paleontologist has been accustomed to accept without much debate the allotments of time that astronomers and students of celestial mechanics have been disposed to assign for its age as a planetary body. Life could not have begun until long after the earth had started on its individual planetary existence. No one knows how long it takes a species of animal or plant to acquire its specific characters or to attain changes in characters that would show the passage of one species into another. Animal and plant life have grown under all possible differences of physical surroundings, and the rate of growth and change is in direct relation to the environment. Some animals have endured through geological ages without change while others have developed changes explosively. It is improbable that there will ever be a basis for estimating how long it takes or has taken for one species to pass into another, or to estimate concretely the endurance of the life of any single species. The beautifully preserved fossils of the ancient life of the Cambrian Period which lies almost at the base of the record of life as registered in the rocks, show such perfection of anatomical detail and such an advanced degree of specialization in organs and functions, that though they stand near the very threshold of the recorded panorama of life, their structure demonstrates that it has taken uncountable ages for them to arrive at such a high degree of specialization. In other words, inasmuch as starts are slow and as the starting point was the nuclear cell, the length of time required in rising from the undifferentiated cell by evolutionary processes to the extraordinary animals of the very ancient Cambrian period must have been vastly greater than all the time that has passed since the Cambrian period to the age of man. The same fact has been made very

evident in the history of plant life. Life came from the sea; it emerged from the surface of the salt waters, but the plant life of the sea which first migrated from the waters to the earliest continents of the earth was of a high order of seaweed or algal growth, that is to say they were algae which had developed strong permanent tissue and special organs. In the view of modern students of paleobotany these so-called "algae of transmigration" were of a higher specialization than any algae now existing in the sea. The time when they got their footing on the land is indicated by the fact that in the ancient Precambrian rocks which make the basement or foundation upon which all later rocks have been laid down, there is positive evidence that at different periods in their own history these rocks were exposed to the air and suffered weathering and so produced a soil, the evidence of which could not have been preserved to this day except through the agency of a contemporary vegetal covering, so that the time of the emergence of plant life of a high order from the sea to the land is far back in the dawn of the time records of the rocks; and the duration of time required for their development longer even than is indicated for the animals. As all estimates of concrete expressions of time for the age of the earth based on biological data are bound to fail, the comparative expressions given herewith must serve to intimate a time duration for the organic history of the earth so vast as to be beyond the possibility of human expression.

Age of the earth from the astronomical viewpoint: ERNEST W. BROWN.

The age of the earth: WILLIAM DUANE. In estimating the age of the earth one should choose as a clock to measure the time that has elapsed some process in nature that takes place in one direction only, and that does not change its rate when conditions (temperature, pressure, etc.) alter. In most of the estimates of geological periods of time that have been made the clocks employed do not fulfill these conditions. Estimates based on the temperature of the earth or sun, for instance, cannot be reliable, for the temperature of a body may rise or it may fall, and, further, the rate of its change depends upon a variety of conditions, such as the amount of radiation, the supply of energy to it, etc. In the study of radioactivity during the last twenty-five years a large number of transformations of one chemical element into another have been found. Students of the subject agree that these transformations take place in one direction only, i. e., from an element of higher atomic weight to an element of lower atomic weight. Further, nobody has been able to alter the rate of a radioactive transformation by any process whatsoever, although numerous attempts have been made to do so. These radioactive changes, therefore, seem to offer a reliable means of estimating certain periods of time. Among the radioactive changes appears one in which the metal uranium transforms itself into the metal lead and into the gas helium. The rate of transformation is such that five per cent. of a quantity of uranium would change into lead and helium in about three hundred and seventy millions of years. If, therefore, we determine the amount of uranium, lead and helium in a mineral we can form an idea as to how long these elements have been in contact with each other. Estimates that have been made from the quantities of helium in uranium ores vary between eight and seven hundred million of years, according to locality. Since some of the helium (it being a gas) may have leaked out of the ores, these intervals of time must be regarded as minimum estimates only. Calculations based on the quantity of lead in uranium ores vary from three hundred and forty to one thousand seven hundred millions of years according to locality. Here another complication appears. All the different kinds of lead do not come from uranium. Only lead of atomic weight, about two hundred and six, may be regarded as produced from uranium. Until, therefore, it has been determined exactly what the atomic weights of the lead in the various ores really are we must consider the estimates as maximum estimates only. The atomic weight of the lead in a few ores has been found to be very close to two hundred and six. In one of these the age of the mineral has been estimated at a little over nine hundred millions of years. The calculation of the age of the uranium deposits rests upon the laws of nature as we now believe them to be. It would be a waste of time to speculate on future discoveries or upon a possible evolution of natural law. The calculated ages are the lengths of time during which we may suppose the chemical elements to have been in more or less close mechanical contact with each other. They do not represent the time that has elapsed since the earth may have reached a state capable of supporting organic life as we now know it.

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